ING DERIVATIVE SPECTROSCOPY OF HYPERSPECTRAL REMOTE-SENSING REFLECTANCES

E. Torrecilla[1], J. Piera[1], D. Stramski[2], R. Reynolds[2], E. Millán-Nuñez[3]
(1) Marine Technology Unit, Mediterranean Marine and Environmental Research Centre (CMIMA-CSIC)
torrecilla@utm.csic.es.
(2) Marine Physical Laboratory, Scripps Institution of Oceanography, Univ. of California San Diego
(3) CICESE, Oceanografia Biologica, México.

Abstract – One of the major challenges of ocean color research is distinguishing phytoplankton groups from in situ, airborne and satellite measurements to better understand diversity of phytoplankton and some involved biochemical processes. In this framework, high spectral resolution measurements of the remote-sensing reflectance, hyperspectral Rrs(λ), can potentially yield more information about the presence of diverse phytoplankton groups than can be gleaned from traditional analyses of single band-ratios at discrete wavelengths (i.e. multispectral approaches). We introduce and discuss the feasibility of performing derivative spectroscopy and cluster analysis of hyperspectral Rrs(λ) to improve the automatic identification of phytoplankton populations in open ocean waters.

Keywords – Ocean bio-optics, derivative spectroscopy, cluster analysis.

I. INTRODUCTION

Marine scientists have had a long term-interest in characterizing the diversity of phytoplankton communities in the ocean and understanding how diversity changes on spatial and temporal scales relevant to environmental and climate changes. The goal of this research is to estimate the diversity of phytoplankton communities from measurements of ocean color and to do so, an hyperspectral approach is proposed. We introduce and discuss the feasibility of performing derivative spectroscopy of hyperspectral remote-sensing reflectances (Rrs(λ)) [1] to improve the identification of phytoplankton assemblages in open ocean waters. The full potential of hyperspectral optical information, as opposed to current multispectral measurements, in combination with development of algorithms for automatic assessment of phytoplankton composition is explored.

II. RESULTS AND DISCUSSION

The dataset analyzed corresponds to measured and modeled optical properties collected along a north-to-south transect in the eastern Atlantic Ocean during the German expedition ANT-XXIII/1 on R/V Polarstern. Stations were first classified into differing phytoplankton assemblages based upon the ratios of dominant accessory pigments to chlorophyll a, obtained through HPLC chromatography (Table 1). Next, numerical simulations with the Hydrolight radiative transfer model [2] were performed to estimate remote-sensing reflectances (Rrs(λ)) for each station. Differences in each station Rrs(λ) (Fig. 1a) were further examined using tools such as derivative spectroscopy and hierarchical cluster analysis, HCA (Fig. 1b).

Different phytoplankton assemblages, identified by HPLC pigment analysis, were automatically classified from cluster analysis of simulated hyperspectral remote-sensing reflectance data. Our analysis indicates that utilizing derivative spectra of hyperspectral remote-sensing reflectance provides better separation between classified stations and the maximum distance between the clusters of classified stations.

III. CONCLUSIONS

The preliminary results suggest that the application of derivative spectroscopy to hyperspectral Rrs(λ) provides an effective means to potentially characterize phytoplankton biodiversity in open ocean environments. Future work will be focused on exploring the potential of the proposed methodology within the framework of NASA Ocean Color Science projects [3].

REFERENCES

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Dominant accessory pigments to Chlorophyll a		Station Label
Fucoxanthin, 19'-Hex-Fucoxanthin		A
Divinyl Chl a, Zeaxanthin	(DV Chl a > Zea)	B
Divinyl Chl a, Zeaxanthin	(DV Chl a ≈ Zea)	C1,C2,C3,C4
19'-Hex-Fucoxanthin, Zeaxanthin	(19'-Hex-Fuco > Zea)	D
19'-Hex-Fucoxanthin, Zeaxanthin	(19'-Hex-Fuco ≈ Zea)	E
19'-Hex-Fucoxanthin, Fucoxanthin	(19'-Hex-Fuco > Fuco)	F

Table 1. Classification of stations into different groups based on phytoplankton community composition, as indicated by the ratios of two dominant accessory pigments to chlorophyll a.

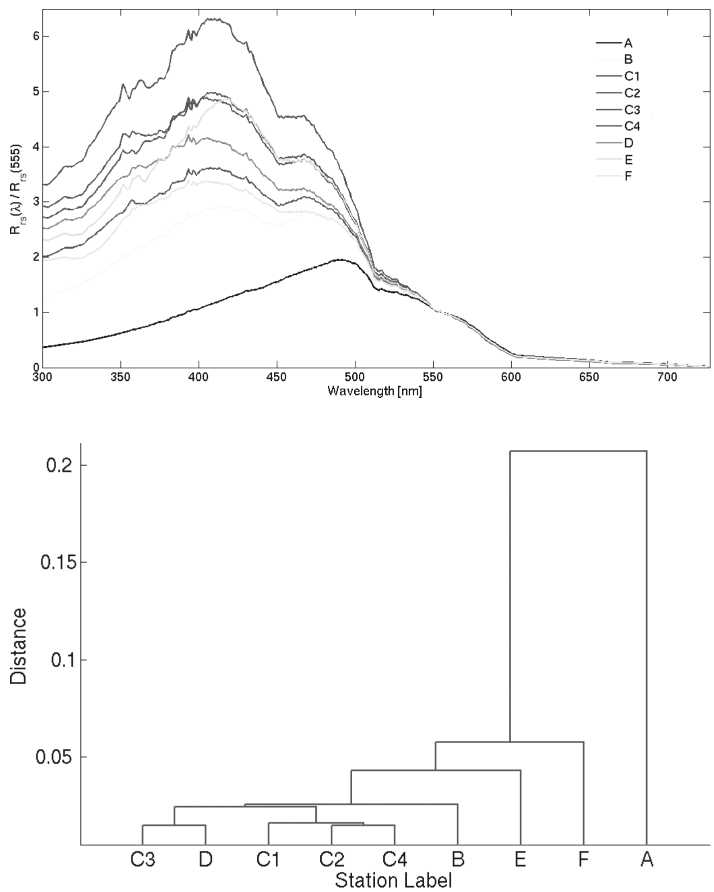

Figure 1. (a) Remote-sensing reflectance (Rrs(λ)) ratios computed for each group of stations (cf. Table 1). (b) Classification of stations based on hierarchical cluster analysis for second derivative of normalized hyperspectral Rrs(λ) spectra shown in Fig. 1(a).